II-303 DISTRIBUTED SNOWMELT SIMULATION OVER LARGE RUGGED BASIN

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INTRODUCTION

For large mountainous basin where is covered by snow in winter, it is necessary to have snowmelt models to predict high snowmelt runoff to dam site during spring. There are many snowmelt runoff models over such basin but most of them are lumped or semi-distributed models .In topoclimatological area or rugged basin which its meteorological factors change elevationally even over short horizontal distance, it seems superior to consider snowmelt model as full-distributed model over large rugged basin especially for short period prediction. In present study, the snowmelt model is considered as distributed one by dividing the basin into various small rectangular sub-basins and heat balance method is applied to simulate snowmelt process at each sub-basin separately.

PROPOSED MODEL CONCEPT

In this study, Okutadami basin which has area about 438 km^2 is selected, the basin is divided into 6829 rectangular grids sized about 278.25m x 231.16m and the elevation of each grid is assigned by using GIS data file KS-110, synthesized mesh-flow directions of the basin is obtained by using this data and shown in **Fig.1**. The locations of snowcover within the basin is obtained from NOAA data which has grid size about 1.1km x 1.1km and transfered to small grid by overlaying.

Components of heat balance are calculated at each grid by considering the variations due to topography. The equation of heat balance when heat gained from precipitation and heat conducted by ground are neglected can be presented by,

$$Q_n = (1-\alpha)R_s + \varepsilon R_l - \varepsilon\sigma T_s^4 + H + lE \qquad \text{..................(1)}$$

where Q_n is net heat gained by snowpack, α is albedo of snow surface, R_s is net incoming solar radiation, ε is snow surface emissivity, R_l is incoming longwave radiation, σ is Stefan-Boltzmann constant, T_s is snow surface temperature, H is sensible heat and lE is latent heat.

Net incoming solar radiation, R_s, is considered varies grid by grid dues to its topographical properties and is shown by the following equation,

$$R_s = Q_s + q_s + q_r \qquad \text{..................(2)}$$

where Q_s is direct solar radiation on inclined surface and will be setted to zero if the sun is checked that is obscured by surrounding grids, q_s is diffuse radiation on inclined surface and q_r is reflected radiation from surrounding area and are expressed as:

$$Q_s = \tilde{Q}_h \cos\gamma/\cos Z_s \ , \ q_s = \tilde{q}_h \cos^2(Z/2), \ q_r = (\tilde{Q}_h + \tilde{q}_h)\sin^2(Z/2) \quad ..(3)$$

$\tilde{Q}_h$ and $\tilde{q}_h$ are direct and diffuse solar radiation terms on horizontal plane under all sky-conditions, the first term is obtained by subtracting global radiation(direct plus diffuse)with the second term. The global radiation is assumed relates to hourly sunshine fraction linearly and analyzed by using measured data at dam site for period of May to June 1991. Diffuse radiation is assumed decreases linearly with hourly sunshine fraction, it equals to global radiation if hourly sunshine fraction is zero and when hourly sunshine fraction equals to one, the diffuse radiation can be estimated indirectly by using empirical formula of direct and global radiation under clear-sky condition developed by **Kondo and Miura(1983)**. Term of $\cos\gamma$ is cosine of angle between solar beam and normal axis of inclined plane, this term is derived vectorially and the result is same as presented by **Garnier and Ohmura(1968)**. Z_s is the sun's zenith angle, Z is zenith angle of plane measured from axis normal to the earth's surface.

Incoming longwave radiation term, R_l, of eq.1 is represented by,

$$R_l = L_h \cos^2(Z/2) + \varepsilon\sigma T_s^4 \sin^2(Z/2) \qquad \text{..................(4)}$$

The first term represents incoming longwave emitted from atmosphere on horizontal surface, L_h, and adjusted for inclined surface and the second term is longwave emitted from surrounding surface, L_h is calculated by using air temperature, cloud amount and vapour pressure.

Sensible heat is calculated by using wind speed and air temperature while these two terms together with relative humidity and air pressure are used to calculate latent heat. Air temperature and air pressure are considered vary with elevation but relative humidity and wind speed are considered to be constant over the basin.

RESULT AND CONCLUSION

The snowmelt model developed by **Kondo and Yamazaki(1990)**is applied to all grids where are covered by snow totally 5729 pixels for period starts from 12:00 AM of 8 May 1988 to 11:00 AM of 11 may 1988 and time step for one hour is selected. Spatial distribution of snowmelt rate over the basin at 12:00 AM of 9 May 1988 is shown in **Fig.2** and distribution of that rate along row = 145 is shown by **Fig.3** for 12:00 AM and 17:00 PM of 9 May 1988. The results show that even the sun is high, the plane characteristics can affect to incoming radiation. For this basin, plane slopes vary from horizontal to above 30 deg. and some grids are in shadow due to the sun is obscured by high surrounding grids during 6 AM to 8 AM and 15 PM to 18 PM. Also the time series of snowmelt at pixel column = 30, row = 120 is shown in **Fig.4**.

REFERENCE

Garnier,B.J. and Ohmura,A.,1968: A method of calculating the direct shortwave radiation income of slopes. J. of Appl. Meteor.,p.796-800.

Kondo,J. and Yamazaki,T.,1990: A prediction model for snowmelt, snow surface temperature and freezing depth using a heat balance method. J. of Appl. Meteor.,p.375-384.

Kondo,J. and Miura,A.,1983: Empirical formula of the solar radiation at the ground level and a simple method to examine an inaccurate pyranometer. Tenki, 30,p.469-475(in Japanese).

Fig.1 Basin mesh-flow directions

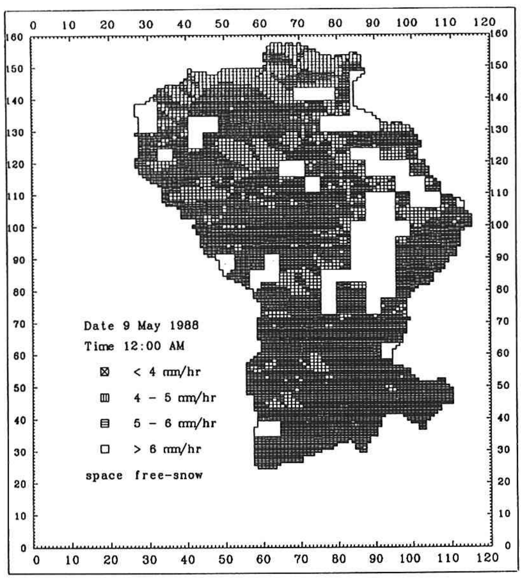

Fig.2 Spatial distributed snowmelt rate

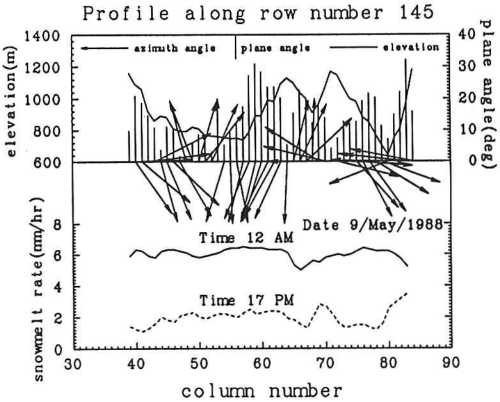

Fig.3 Snowmelt rate along row no.145

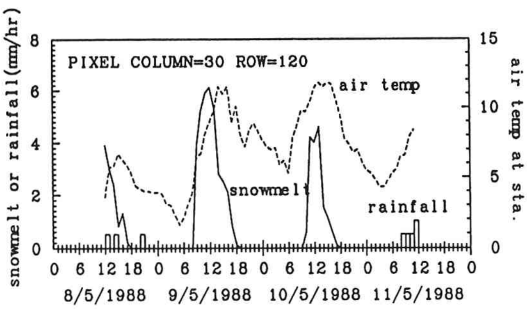

Fig.4 Time variation of snowmelt rate at a particular pixel